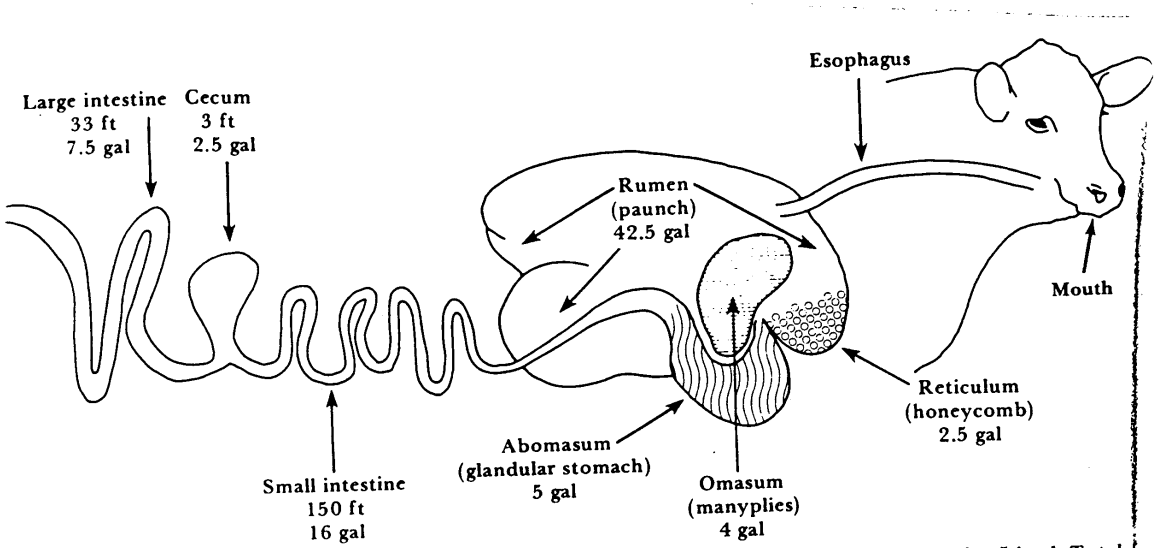
Ruminant Digestive System

- Complex structure with four compartments



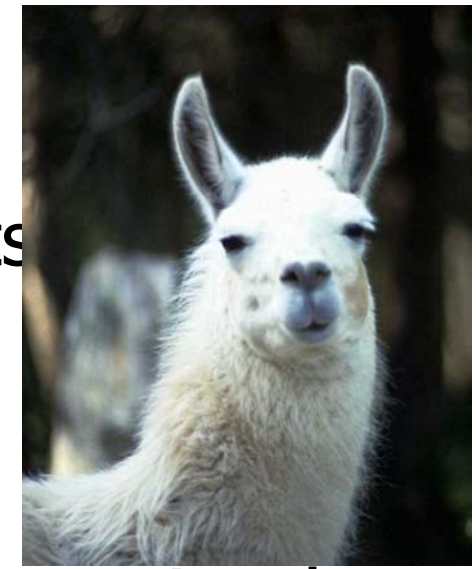
Complex digestive tract—20 X body length. Chews after fermentation (ruminates). Stomach capacity 54 gal. Total capacity 80 gal. 32 teeth.

FIGURE 1–9. Digestive system of the ruminant (cow).

Source: Animal Feeding and Nutrition (Jurgens)

Ruminant Characteristics

- Primarily herbivores
  - Cattle, sheep, goats, deer, elk
  - Camelids are "pseodu" ruminants



- 60-75% of ingesta fermented by microbes <u>before</u> exposed to gastric juices

Mouth

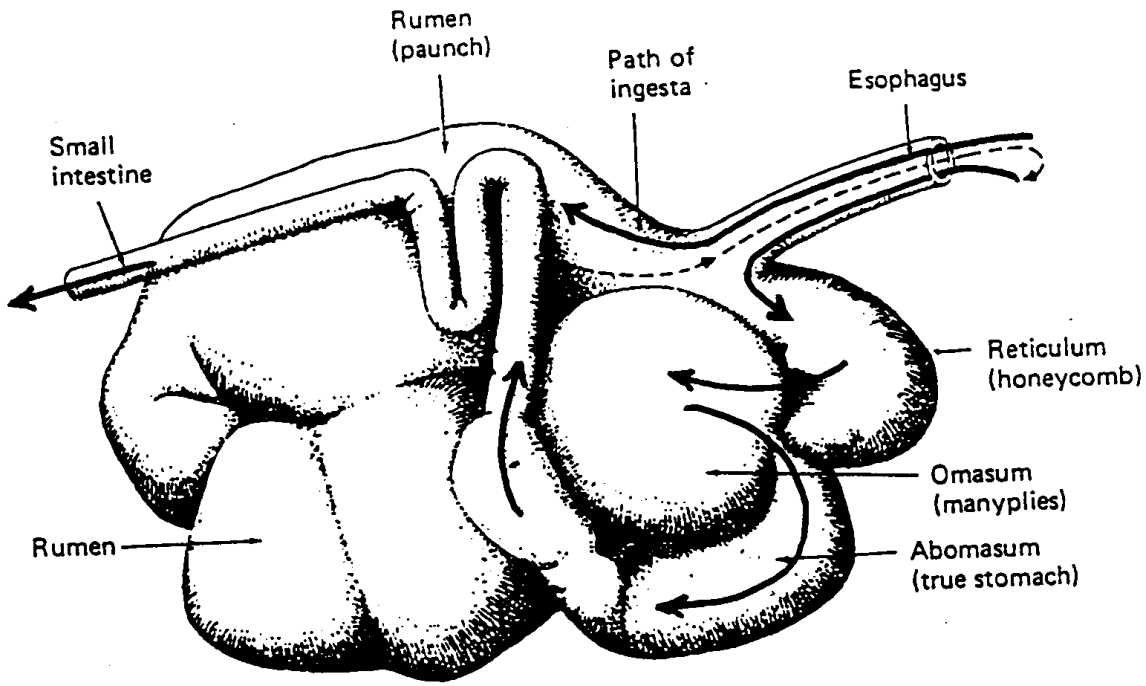
- Tongue
  - Used more by cattle and goats (also use lips)
- Teeth
  - No upper incisors
  - Used more by sheep (use lips to “sort” feed)
- Saliva
  - Continual production
  - Cattle: 12 gal/d vs Sheep: 2 gal/d
  - No enzymes; High pH

Esophagus

- No sphincter valve
- Opens into reticulum and rumen
- Muscle contractions move in both directions

Stomach compartments

- Reticulum
- Rumen
- Omasum
- Abomasum



A higher proportion of a ruminant's digestive system is stomach

Reticulum characteristics

- Located next to heart
- Honeycomb appearance
  - Catches metal and hardware
- Pathways
  - Esophagus
  - Rumen
  - Omasum
- No enzymes secreted

Rumen Characteristics

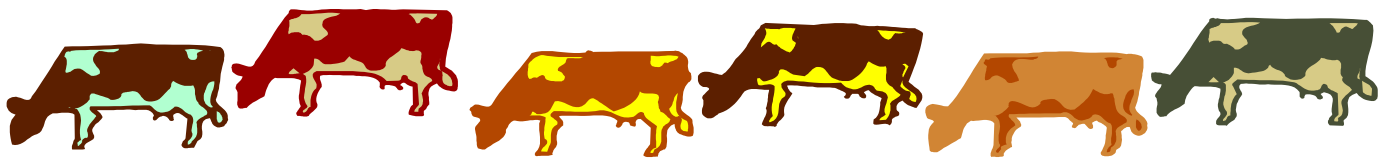
- Left side of abdomen
- Papillae lining
- Muscular pillars
- Fermentation vat
  - Primarily anaerobic
  - Some aerobic microbes
- Not functional at birth

Rumen Functions

- Storage
- Soaking
- Physical mixing and breakdown
- Fermentation
  - Synthesizes some vitamins
  - Synthesizes AA and protein
  - Breaks down fibrous feeds into VFAs

Volatile Fatty Acids (VFAs)

- Acetic Acid
- Butyric Acid
- Propionic Acid



Omasum

- "Manyplies"
- No enzymes from walls
- Function
  - Reduce particle size
  - Absorb some water

Abomasum

- "True stomach" that secretes enzymes from walls

- Glandular stomach like monogastric fundic region
  - HCL, Mucin
  - Pepsinogen, Rennin and Lipase

Small and Large Intestine

- Same SI sections
  - Duodenum, Jejunum and Ilium
- Same LI sections
  - Cecum, Colon and Rectum

Ruminant Differences

- Esophageal Groove
  - By passes reticulum and rumen in young animals
- Rumination
  - Chew their cud (food bolus)
  - Up to 8 hours/day
    - Decrease particle size for microbes
    - Increases saliva production to buffer rumen
  - About 30 times/day

Ruminant Differences con't

- Eructation (belching)
  - CO_2 and Methane
  - Produced by microbial population in rumen
  - Rumen contracts and forces gas out
  - Bloat can result if ruminant doesn't belch

Bloat

Gas can’t escape

Animal dies from suffocation because of distended rumen

Digestive Fluids

- Saliva
  - Review
- Gastric juices from stomach
  - Pepsinogen
  - Rennin
  - Lipase
  - HCL

Digestive Fluids con't

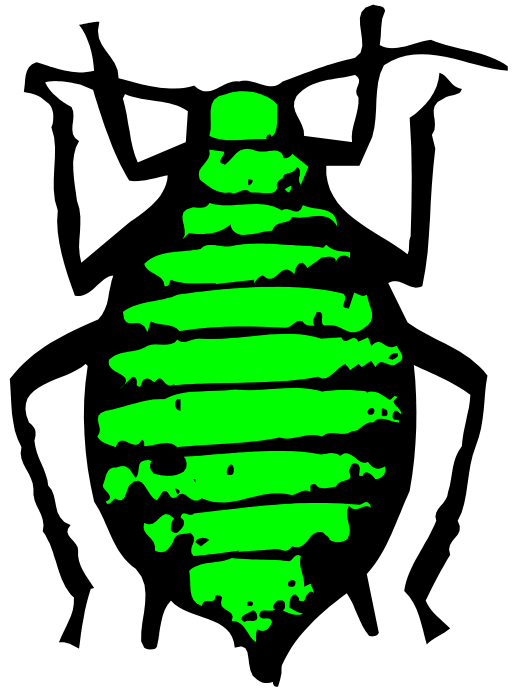
- Pancreatic secretions
  - Trypsin, Chymotripsin, Carboxypeptidase
  - Amylase
  - Lipase
  - Buffers
- Liver Secretions
  - Bile salts; No enzymes

Digestive Fluids con't

- Intestinal enzymes
  - Aminopeptidase, Dipeptidase, Nucleases
    - Denaturing proteins
  - Maltase
  - Lactase
  - Sucrase

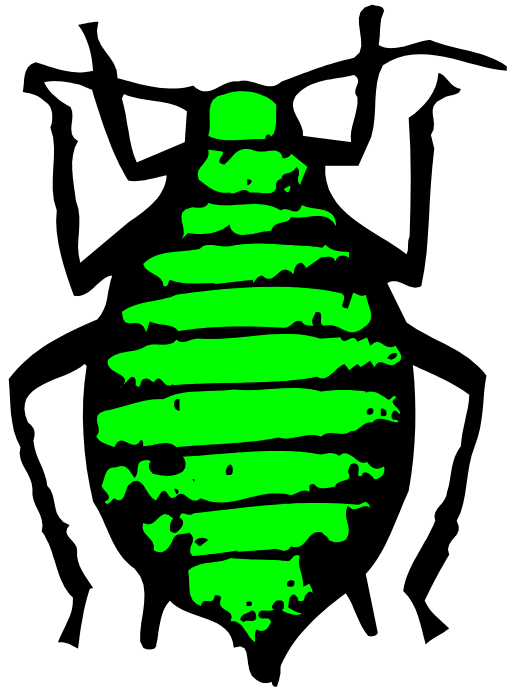
Microbial Fermentation

- Short Life cycle
- Synergistic relationship
- Types of microbes
  - Starch fermenters
    - Amylotic microbes
  - Cellulose/roughage fermenters
    - Cellulolytic microbes
  - Adjust according to diet



Microbial Fermentation con't

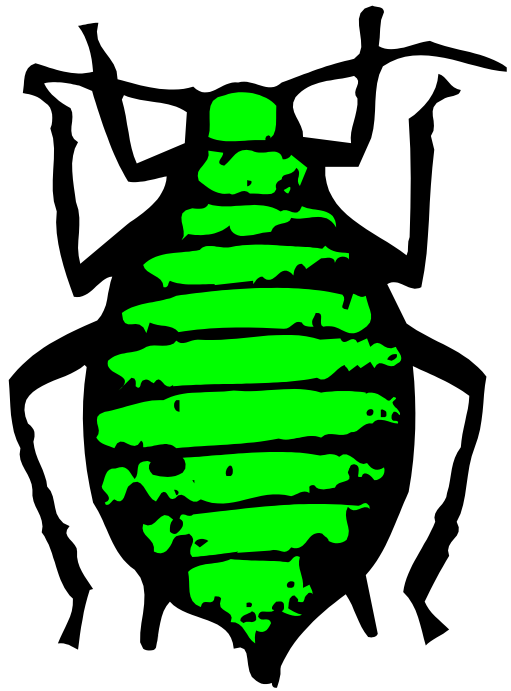
- Categories of microbes
  - Bacteria
  - Protozoa
  - Fungi
  - Bacterial viruses



Note: Type present depends on diet being fed

Microbial Fermentation

- Regulation of microbes
  - Bacteria vs Protozoa
  - Competition
  - Acidic environment
  - Shifts with diet
  - Shifts with consumption



Rumen Activities

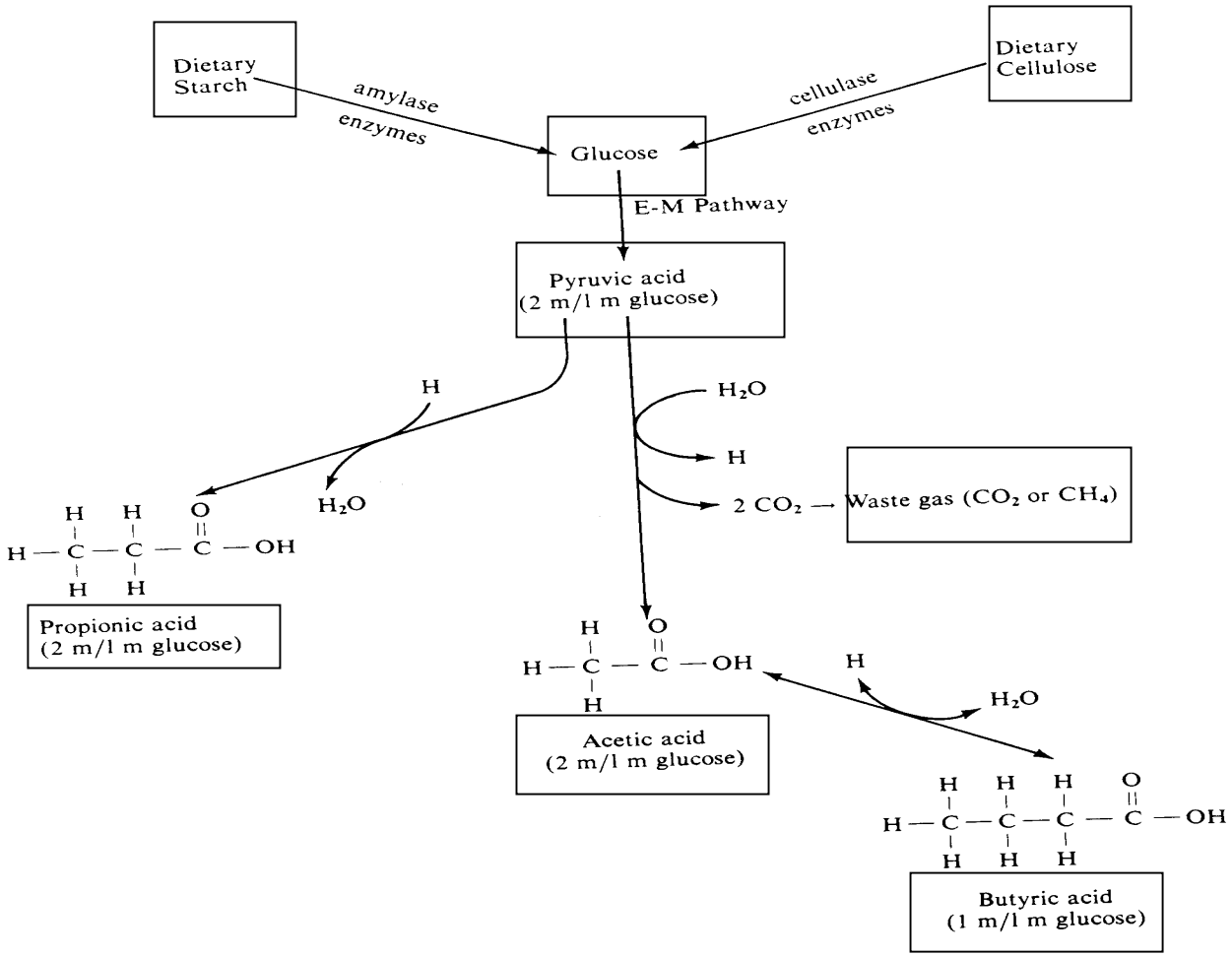


FIGURE 1–3. Volatile fatty acid formation in the rumen.

Source: Animal Feeding & Nutrition (Jurgens)

Volatile Fatty Acids (VFAs)

- Acetic Acid (Acetate)
  - Most comes from cellulose
  - Important to milk fat in dairy cows
- Propionic Acid (Propionate)
  - Most comes from starch
- Butyric Acid (Butyrate)
  - Derived from Acetic acid

Notes on VFAs

- Pyruvic Acid → Acetic Acid
  - CO_2 and CH_4 given off
- Ionophore Feed additives
  - Increases production of propionic acid
  - Decreases production of acetic acid

Normal Process

- Propionic → Lactic Acid
  - Normal microbial process
  - Lactic acid lower pH
- Lactic Acid → Pyruvate
  - Lactic Acid fermenters required
  - Pyruvate is converted to glucose in liver
  - Conversion of lactic acid restores pH balance

Quick Diet Changes

- Propionic → Lactic Acid
  - Lactic acid lowers pH
- Lactic Acid → Pyruvate
  - Lactic Acid fermenters are slow growing
  - Can't keep up so pH is not restored
  - Low pH kills microbes
  - Animal often dies of lactic acidosis

Causes of Lactic acidosis:

- Quick diet changes to high concentrates
- Removal from feed
- Restriction of feed intake during stress
- Voluntary feed aversion
  - Palatability
  - Character

- All of these cause microbial imbalance

Questions to ponder….

- Review what happens when you suddenly switch from high roughage to high grain…..

- What happens to an animal if you suddenly switch from a high grain to a high roughage diet?

End products of Ruminant Digestion

- VFAs
  - Main energy source for cows
- CO_2
- CH_4 (Methane)
- NH_3 (Ammonia)
- Microbes

Importance of pH in Digestion

- Optimum is 6.8
- Factors affecting pH
  - Diet
    - Hay versus Grain
  - Level of intake
  - Frequency of intake
- Regulating pH

Types of Microbes

- Starch Fermenters
- Cellulose/roughage Fermenters
- Understanding consequences of quick changes in diet

Rumen Development

- 48 -100 liters of liquid
  - Larger in cows on a forage diet
  - Forage-fed calves have larger rumens
- 15-21% of mature cow weight is rumen contents

DIGESTIVE TRACT CAPACITY

	HEN	PIG	HORSE	COW
1. STOMACH (%)	57	29	8	67
A. RUMEN				53
B. RETICULUM				3
C. OMASUM				5
D. ABOMASUM				6
E. CROP	43			
F. PROVENTRICULUS	0.3			
G. GIZZARD	14			
2. SMALL INTESTINE (%)	26	34	25	20
3. CECUM (%)	6	4	18	3
4. LARGE INTESTINE (%)	10	32	48	9
TOTAL CAPACITY (GAL.)	.02	7	45	80

Rate of Passage

- Definition
  - How fast food passes through the rumen
- General trends with various feedstuffs
  - Ground vs Stem Hay
  - Concentrates
- Why important?

Last tidbits on Microbes

- Microbe development in young ruminants
- Probiotics
  - Definition- Feed additive for steers
  - Purpose
- Antibiotics
  - Effects on microbes